# 9

# Ground Water Monitoring

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## Introduction

Lawrence Livermore National Laboratory regularly samples and analyzes ground waters in the Livermore Valley and in the Altamont Hills. LLNL maintains multiple ground water monitoring programs to comply fully with environmental regulations, DOE orders, and the requirements of the Ground Water Protection Management Program (GWPMP). The two main objectives of the ground water monitoring programs described in this chapter are to measure compliance with waste discharge requirements and post-closure plans and to assess the impact, if any, of LLNL operations on ground water resources.

U.S. Department of Energy (DOE) Order 5400.1 and the to-be-promulgated 10 CFR 834 require all DOE facilities to prepare a GWPMP that describes the site's ground water regime, areas of known contamination, remediation activities, programs to monitor the ground water, and the means to monitor and control potential sources of ground water contamination. Considerable ground water monitoring and remediation, discussed in Chapter 8, is carried out under Comprehensive Environmental Response Compensation and Liability Act (CERCLA) restoration efforts. Soil and sediment surveillance monitoring under the GWPMP is described in Chapter 10. Additional programs address the sanitary sewer system, building drains, and underground storage tanks.

## *Surveillance Monitoring*

Ground water monitoring at LLNL complies with DOE Order 5400.1, which affirms DOE's commitment to protect the environment. LLNL conducts surveillance monitoring of ground water in the Livermore Valley and in the Altamont Hills through networks that include private off-site wells and on-site wells. The two monitored areas and their aquifers are separated by a major drainage divide. The Livermore site in the Livermore Valley drains to San Francisco Bay via Alameda Creek. Most of Site 300 drains to the San Joaquin River via Corral Hollow Creek, with a small undeveloped portion in the north draining to the north and east toward Tracy. In order to have a comprehensive, cost-effective monitoring program, LLNL determines the number and locations of surveillance wells, the analytes to be monitored, the frequency of sampling, and the analytical methods to be used.

A wide range of analytes is monitored to assess the impact of current LLNL operations on local water resources. Because surveillance monitoring is geared to detecting analytes at very low concentrations in ground water, it can detect contamination before it significantly impacts ground water resources. Wells at the Livermore site, in the Livermore Valley, and at Site 300 in the Altamont Hills are included in LLNL's surveillance monitoring plan.

## *Compliance Monitoring*

The Compliance Ground Water Monitoring Program complies with numerous federal and state controls (see Chapter 2, **Table 2-4**, for a summary of LLNL permits). Compliance monitoring of ground water is conducted at Site 300 to satisfy state-issued permits associated with closed landfills containing solid wastes and with continuing discharges of liquid waste to surface impoundments, sewage ponds, and percolation pits. Ground water compliance monitoring at Site 300 is specified in Waste Discharge Requirement (WDR) orders issued by the Central Valley Regional Water Quality Control Board (CVRWQCB) and in landfill closure and post-closure monitoring plans. The WDRs and post-closure plans specify wells and effluents to be monitored, constituents of concern (COCs) to be measured, measurement frequency, inspections to be conducted, and the frequency and form of required reports. These monitoring programs include quarterly and semiannual monitoring of ground water, monitoring of various influent waste streams, and visual inspections. LLNL conducts additional operational monitoring of wastewater effluents discharged to surface impoundments and sewage ponds to comply with WDRs issued under California's Porter-Cologne Water Quality Control Act. Quarterly and annual written reports of analytical results, inspection findings, and maintenance activities are required for each monitoring network.

## *Livermore Site and Environs*

### *Livermore Valley*

LLNL has monitored tritium in water hydrologically downgradient of the Livermore site since 1988. Tritium is potentially the most mobile ground water contaminant emanating from LLNL. Rain and storm water runoff in the Livermore Valley, which recharge local aquifers, contain small amounts of tritium from natural sources, past worldwide atmospheric nuclear weapons tests, and atmospheric emissions from LLNL. (See Chapters 4, 5, and 7 for further discussion of air emissions, rain, and storm water runoff.) Ground water samples were obtained during 1998 from 20 wells in the Livermore Valley (**Figure 9-1**) and measured for tritium activity.

Ground water is recharged at the Livermore site from arroyos and by rainfall. Recharge enters primarily through the arroyos (see also Chapter 7). Ground water flow at the Livermore site, which is generally westward, is discussed generally in Chapter 1 and in detail in the *CERCLA Remedial Investigation Report for the LLNL Livermore Site* (Thorpe et al. 1990) and the annual LLNL Ground Water Project reports.

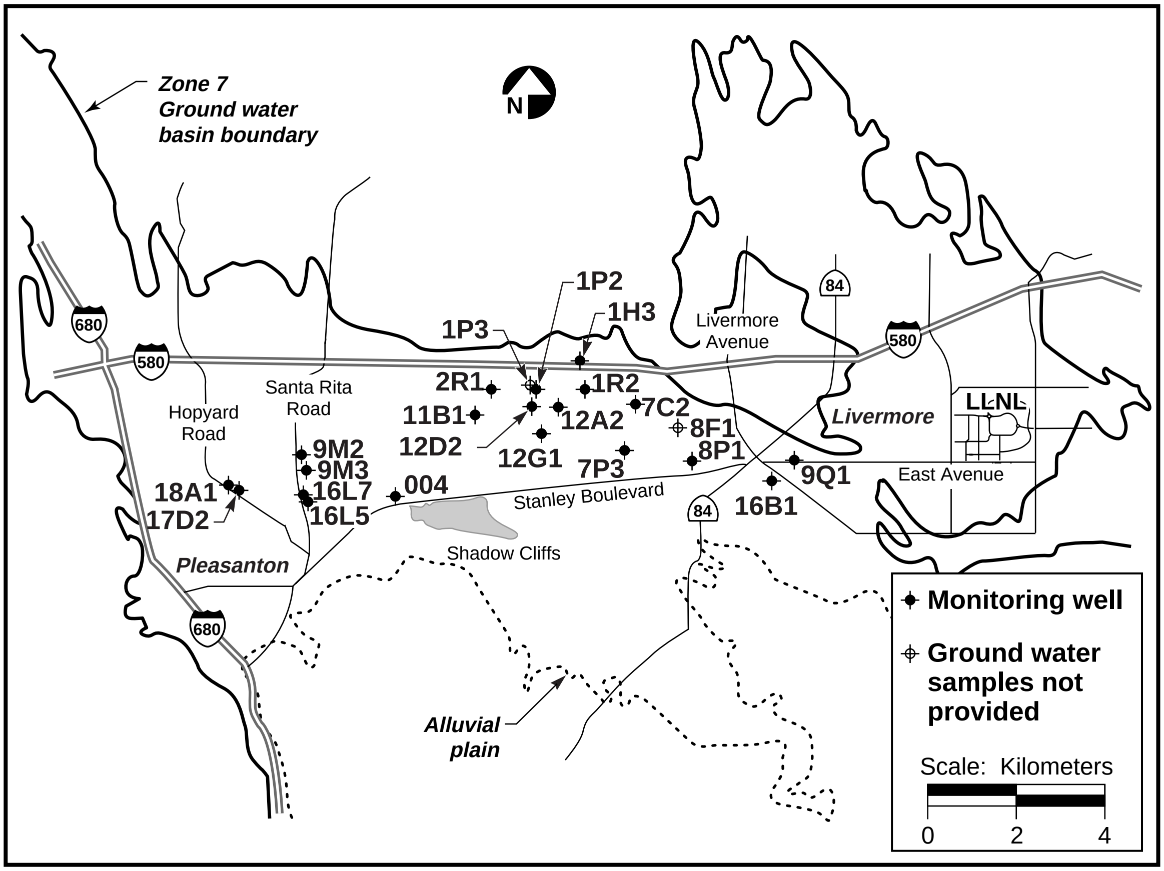


**Figure 9-1.** Locations of off-site tritium monitoring wells in the Livermore Valley.

### *Livermore Site Perimeter*

LLNL designed a surveillance monitoring program to complement the Livermore Ground Water Project (discussed in Chapter 8). The intent of this network is to monitor for possible contaminants other than volatile organic compounds (VOCs), which are handled under the Livermore Site Ground Water Project. The perimeter portion of this surveillance ground water monitoring network makes use of two upgradient monitoring wells near the eastern boundary of the site and seven downgradient monitoring wells near the western boundary (**Figure 9-2**). Downgradient wells located in the regions of Treatment Facilities A, B, and C (see **Figure 8-1**) meet the requirements of DOE Order 5400.1. These seven downgradient wells monitor the uppermost aquifers for COCs that are outside the areas where ground water is being treated.

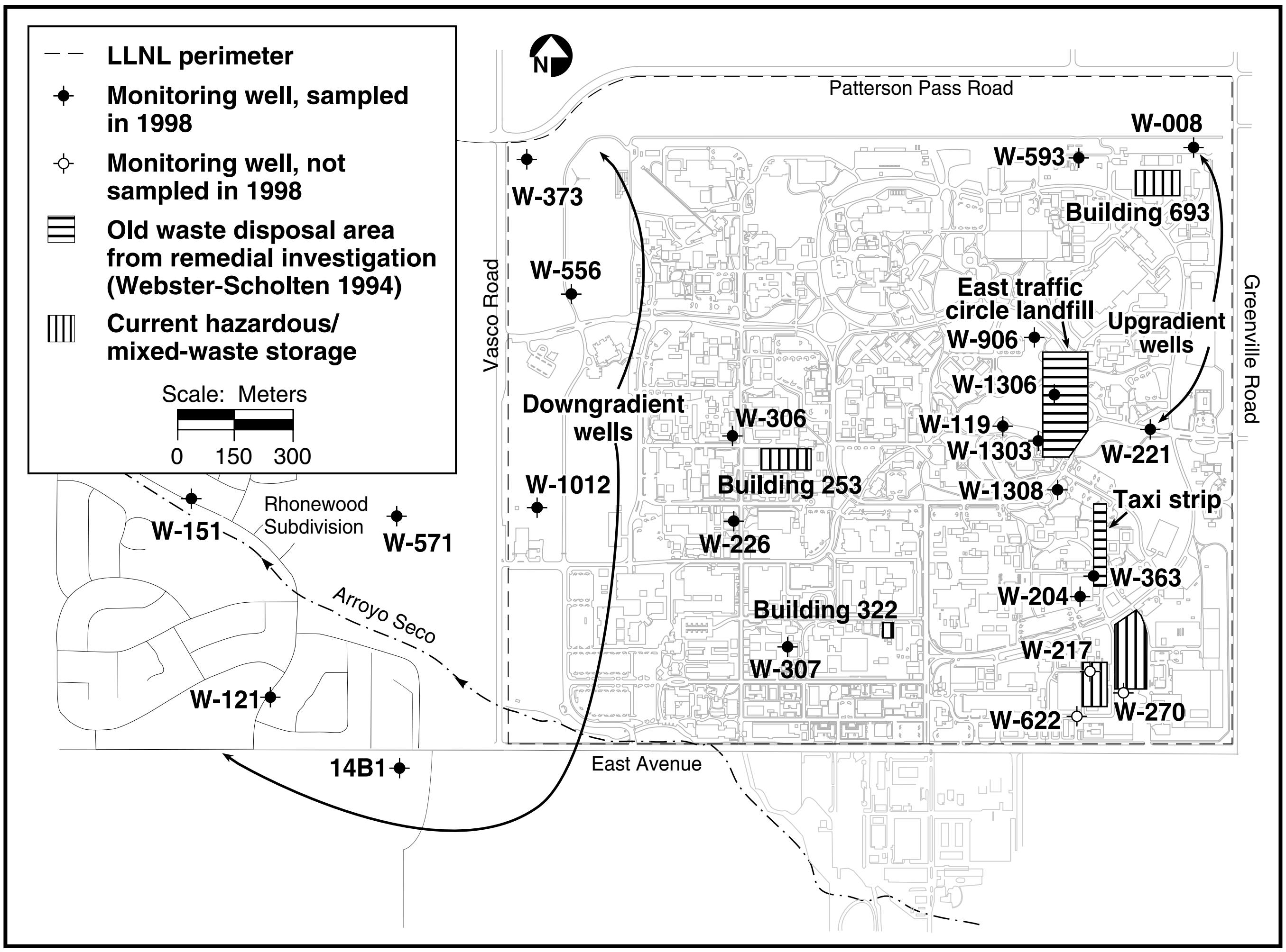


**Figure 9-2.** Locations of routine surveillance ground water monitoring wells at the Livermore site.

The two upgradient wells were sampled and analyzed semiannually for nonradioactive constituents and quarterly for most radioactive constituents in order to obtain sufficient data for statistical analyses; the seven downgradient wells were sampled and analyzed annually for nonradioactive constituents and semiannually for most radioactive constituents. Each well was sampled and the water analyzed for metals and minerals, herbicides, gross alpha and beta, tritium, and other radioisotopes. Routine surveillance monitoring data for 1998 are presented in the Data Supplement (Tables 9-1 through 9-9). These monitoring results will help establish baseline conditions for future monitoring and detect the presence of any contaminants of concern to public health or to the environment.

### *Livermore Site*

Livermore site ground water sampling locations include areas where releases to ground may have occurred in the recent past or where previously detected COCs have low concentrations that do not require CERCLA remedial action. Monitoring wells screened in the uppermost aquifers are situated downgradient from, and as near as possible to, the potential release locations. The Taxi Strip Area and the East Traffic Circle Landfill are two potential sources of ground water contamination that were added to the surveillance monitoring network in 1997 (see **Figure 9-2**).

Ground water samples from monitoring wells screened in hydrostratigraphic units (HSU) 2 and 3A downgradient from the Taxi Strip Area and East Traffic Circle Landfill were analyzed for americium, plutonium, thorium, uranium, gross alpha and beta radiation, radium-226, radium-228, tritium, strontium-90, metals, polychlorinated biphenols (PCBs), herbicides, general minerals, and radioisotopes by gamma spectroscopy. The locations of these wells—W-119, W-906, W-1303, W-1306, and W-1308—are shown in **Figure 9-2**. (The hazardous waste / mixed waste storage facilities around Buildings 514 and 612 are monitored by four wells. These wells were not sampled in 1998 but are scheduled to be sampled in 1999.) HSUs are described in Chapter 8 and shown in **Figure 8-1**. All surveillance monitoring analytical data for the Taxi Strip Area and the East Traffic Circle Landfill are presented in Data Supplement Tables 9-10 through 9-16.

Another potential source of ground water contamination is the Mixed-Waste Storage Facility in the area of Building 693. Ground water samples were obtained downgradient from this facility during 1998 and were analyzed for the same suite of analytes as the East Traffic Circle Landfill and Taxi Strip Area (see Data Supplement Table 9-17).

Ground water samples were also obtained downgradient from areas where minor releases of metals to ground have occurred. Samples were obtained from monitoring well W-307 (screened in HSU 1B), downgradient from a fume hood vent on the roof of Building 322. Soil samples obtained from the area show elevated concentrations (in comparison with LLNL's site background levels) of chromium, copper, lead, nickel, zinc, and occasionally other metals. LLNL developed a plan for cleaning contaminated soils near Building 322 that is to be implemented in 1999.

Ground water samples were also obtained downgradient from a location where sediments containing metals (including mercury and chromium) had accumulated in a storm water catch basin near Building 253. These ground water samples were obtained from monitoring wells W-226 and W-306 screened in HSUs 1B and 2, respectively. Analytical results for dissolved metals in these samples are presented in Data Supplement Table 9-18.

## Site 300

Monitoring of ground water at Site 300 utilizes on-site DOE wells and off-site private wells. Ground water samples from wells are routinely measured for various elements (primarily metals), a wide range of organic compounds, nitrate, general radioactivity (gross alpha and gross beta), uranium activity, and tritium activity. Typically, Environmental Protection Agency- (EPA-) approved methods are selected for their high sensitivity. (See Data Supplement Table 9-19 for a complete list of COCs and the EPA, or other standard analytical methods, used to measure them.)

**Figure 9-3** shows the ground water sampling locations at, and near Site 300 that utilize wells and springs. Although ground water from the uppermost water-bearing zone is the target of most of the sampling locations, at several locations up to three vertically separated water-bearing zones are sampled by means of multiple-completion installations fitted with Barcad devices. Barcads are identified in **Figure 9-3** by the capital letters A, B, and C at the end of a monitoring installation's identifier code. ("A" is assigned to the Barcad that samples the deepest, or deeper, water-bearing zone.)

Twelve ground water monitoring locations are off site. Two springs in the Altamont Hills, identified as MUL2 and VIE1, are near the northern boundary of Site 300. Off-site surveillance well VIE2 is located 6 km west of Site 300 in the upper reaches of the Livermore Valley watershed. Nine off-site surveillance locations are wells located near the southern boundary of Site 300 in, or adjacent to, the Corral Hollow Creek floodplain.

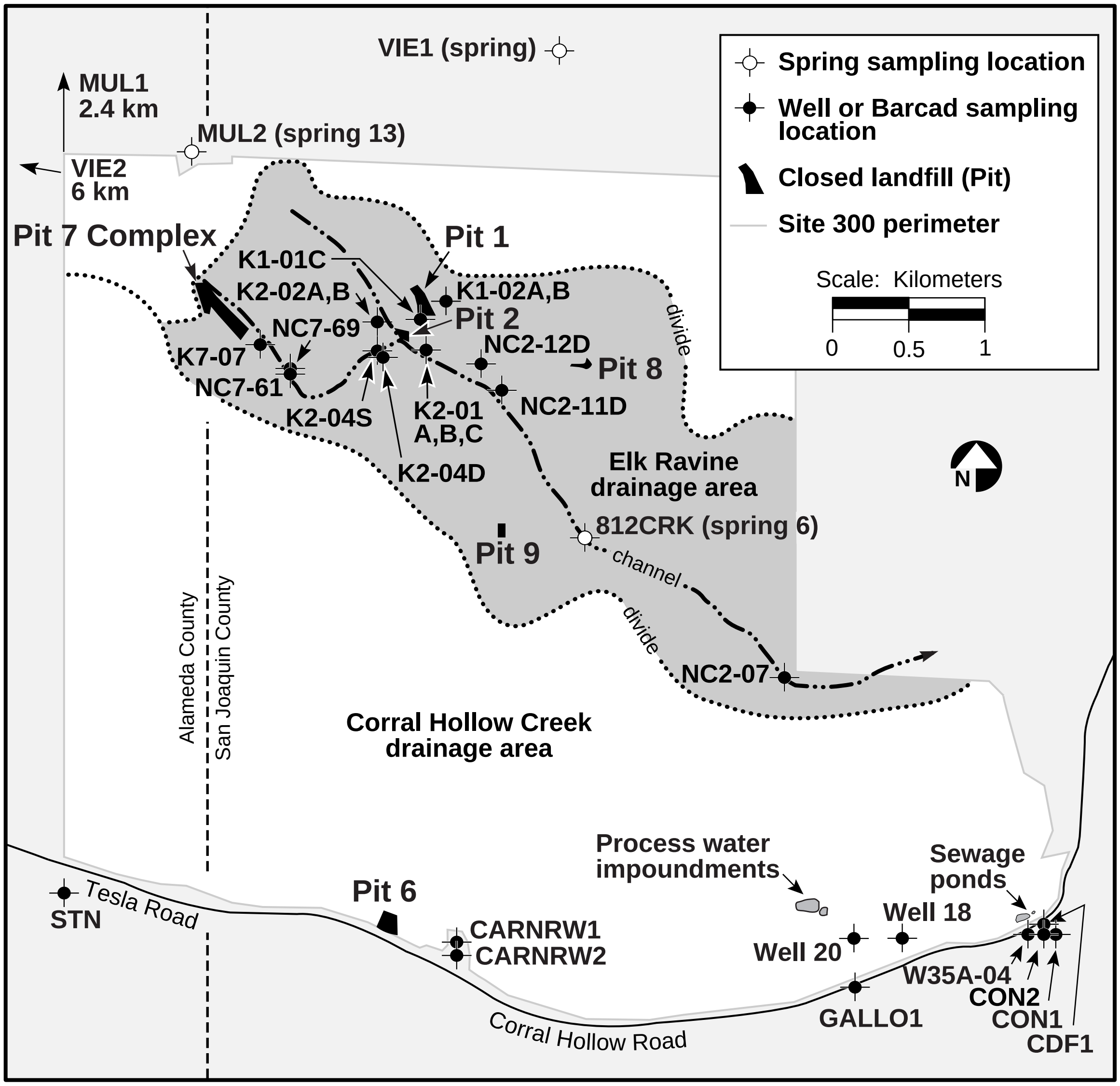


**Figure 9-3.** Locations of surveillance ground water wells, Barcads, and springs, Site 300.

On-site wells that were installed for CERCLA characterization studies during the 1980s continue to be used to monitor closed landfills, surface water impoundments, and sewer ponds. The closed landfills—which are identified as Pit 1, Pit 2, Pit 7 complex, Pit 8, and Pit 9—are located in the Elk Ravine drainage area, while Pit 6, two surface impoundments, and a sewer pond are located in the Corral Hollow Creek drainage area. Two on-site water production wells, Well 18 and Well 20, are also used for surveillance monitoring of ground water at Site 300. Well 20 provides potable water to the site. Well 18 is maintained as a standby supply well.

# 9 Ground Water Monitoring

Brief descriptions of the Site 300 ground water monitoring networks are given below. Tables of the ground water measurements made during 1998 are presented in the Data Supplement that accompanies this volume.

### *Elk Ravine Drainage Area*

The Elk Ravine drainage area, a branch of the Corral Hollow Creek drainage system, includes most of northern Site 300 (**Figure 9-3**). Storm water runoff from closed landfills within the Elk Ravine drainage area (Pits 1–5 and 7–9) collects in arroyos but quickly infiltrates into the ground. Ground water from wells that lie within the Elk Ravine drainage area are monitored for COCs because of the system of surface and underground flows that connect the entire Elk Ravine drainage area.

#### *Pit 7 Complex*

Monitoring requirements for the closed Pit 1 and Pit 7 landfills in the Elk Ravine drainage area are specified in *Waste Discharge Requirements Order 93-100* (WDR 93-100) administered by the CVRWQCB (1993 and 1998) and in *LLNL Site 300 RCRA Closure and Post-Closure Plans— Landfill Pits 1 and 7* (Rogers / Pacific Corporation 1990).

The Pit 7 complex area is located at an elevation of about 400 m in the most elevated portion of the Elk Ravine drainage area. The complex comprises four adjacent landfills identified as Pits 3, 4, 5, and 7 (**Figure 9-4**). From 1963 to 1988, the landfills received waste gravels removed from firing tables at Site 300. The gravels contained concrete, cable, plastic, wood, tritium, depleted uranium, beryllium, lead, and other metals in trace amounts. In 1988, 9440 $m^3$ of gravel were removed from six firing tables at Site 300 and placed in Pit 7 (Lamarre and Taffet 1989). These were the last solid wastes to be placed in any landfills at Site 300.

Ground water samples were obtained quarterly from Pit 7 monitoring wells and analyzed for elements, general radioactivity, tritium, radium-226, uranium (234, 235, and 238), thorium (228 and 232), energetic compounds, and VOCs (EPA Method 601). Field measurements of ground water depth, temperature, pH, and specific conductance were obtained at each well at the time of sample collection.

#### *Elk Ravine*

Ground water samples were obtained twice during 1998 from 8 of 10 Elk Ravine surveillance monitoring wells. Wells K2-01C and NC2-11D had inoperative pumps and were sampled only once. Samples of ground water were analyzed for elements, nitrate, energetic compounds, VOCs, general radioactivity, tritium, and total uranium.

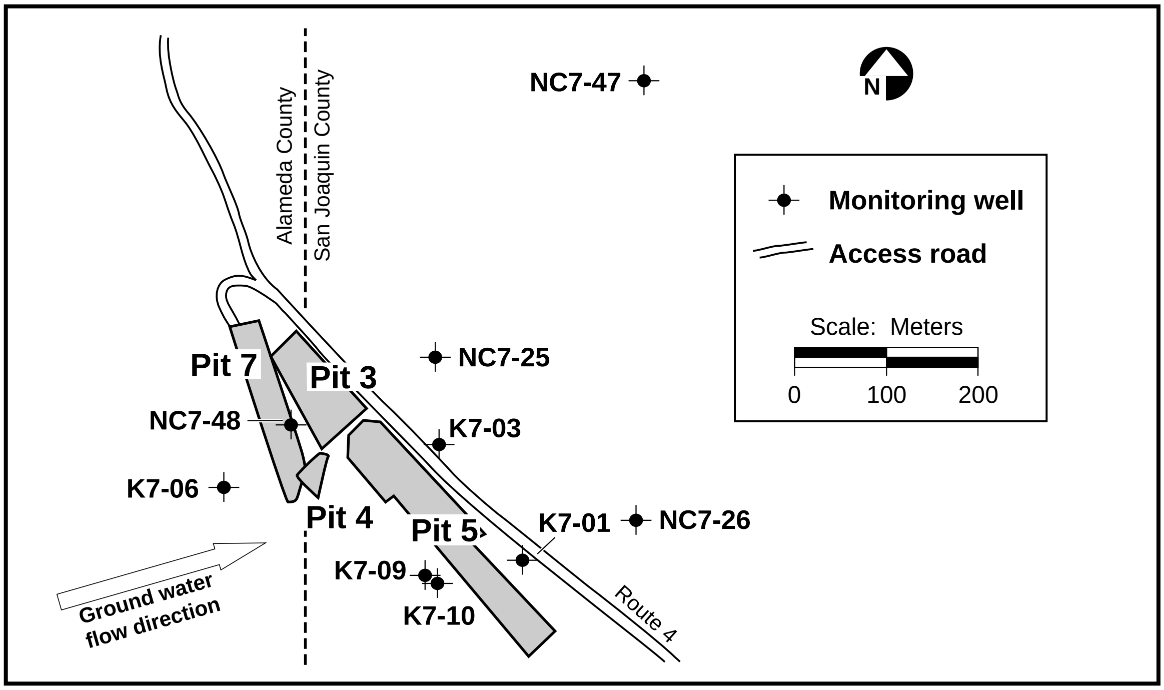


**Figure 9-4.** Locations of compliance ground water monitoring wells, Pit 7 complex.

*Pit 2*

The closed Pit 2 landfill lies in the upper portion of Elk Ravine, about 320 m above sea level (**Figures 9-3** and **9-5**). The landfill primarily contains gravels and debris from hydrodynamic tests of explosive devices conducted at the Building 801 and 802 firing tables. The buried waste material contains depleted uranium and trace amounts of beryllium, thorium, and (possibly) tritium.

Pit 2 ground water samples were obtained twice during 1998. Samples were analyzed for 18 elements, nitrate, VOCs; energetic compounds, general radioactivity, tritium, and total uranium.

*Pit 1*

The RCRA-closed Pit 1 landfill and the positions of the eight ground water wells used to monitor it are shown in **Figure 9-5**. Pit 1 lies in the Elk Ravine drainage area about 330 m above sea level.

Ground water samples were obtained quarterly from Pit 1 monitoring wells during 1998, and they were analyzed for elements, nitrate, general radioactivity, tritium, radium-226, uranium (234, 235, and 238), thorium (228 and 232), and energetic

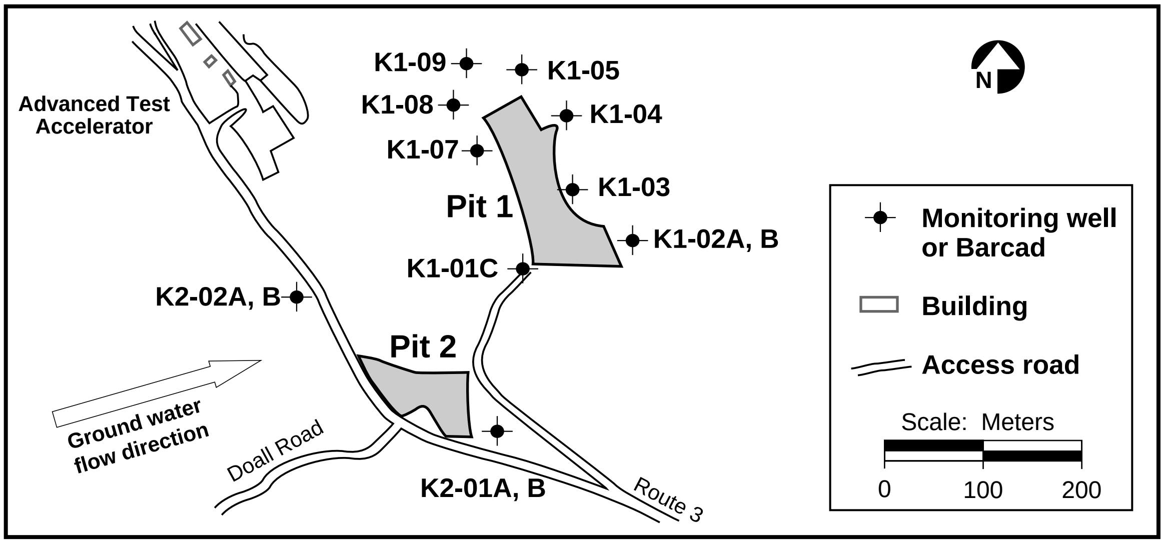


**Figure 9-5**. Locations of Pit 2 surveillance Barcads (K1-02A, K2-01A, K2-01B, and K2-02A) and surveillance well K2-02B, and Pit 1 compliance ground water monitoring wells (K1-01C, -07, -02B, -03, -04, -05, -08, and -09).

compounds. Semiannual measurements were made for an additional seven elements. Field measurements of ground water depth, temperature, pH, and specific conductance were obtained at each well at the time of sample collection. Annual measurements were made for organic compounds (EPA Methods 601, 608, 624, and 625), total dissolved solids (TDS), total organic carbon (TOC), and total organic halides (TOX).

### *Pit 8*

The closed Pit 8 landfill is located in the Elk Ravine drainage area adjacent to the Building 801 firing table, where explosives experiments were conducted from 1958 to 1974. Approximately 40 $m^3$ of untreated debris from the firing table were placed in the pit during that time. Buried debris may contain trace amounts of tritium, depleted uranium, lead, and beryllium.

**Figure 9-6** shows the Building 801 and Pit 8 areas and the locations of the monitoring wells. The pit is located in a narrow ravine within the Elk Ravine drainage area about 350 m above sea level. Chemical analysis of soil and rock samples obtained from this area during CERCLA remedial investigations showed no elevated concentrations of COCs (Webster-Scholten 1994). However, low concentrations of trichloroethylene (TCE) have been detected in ground water samples from upgradient well K8-01 since 1987.

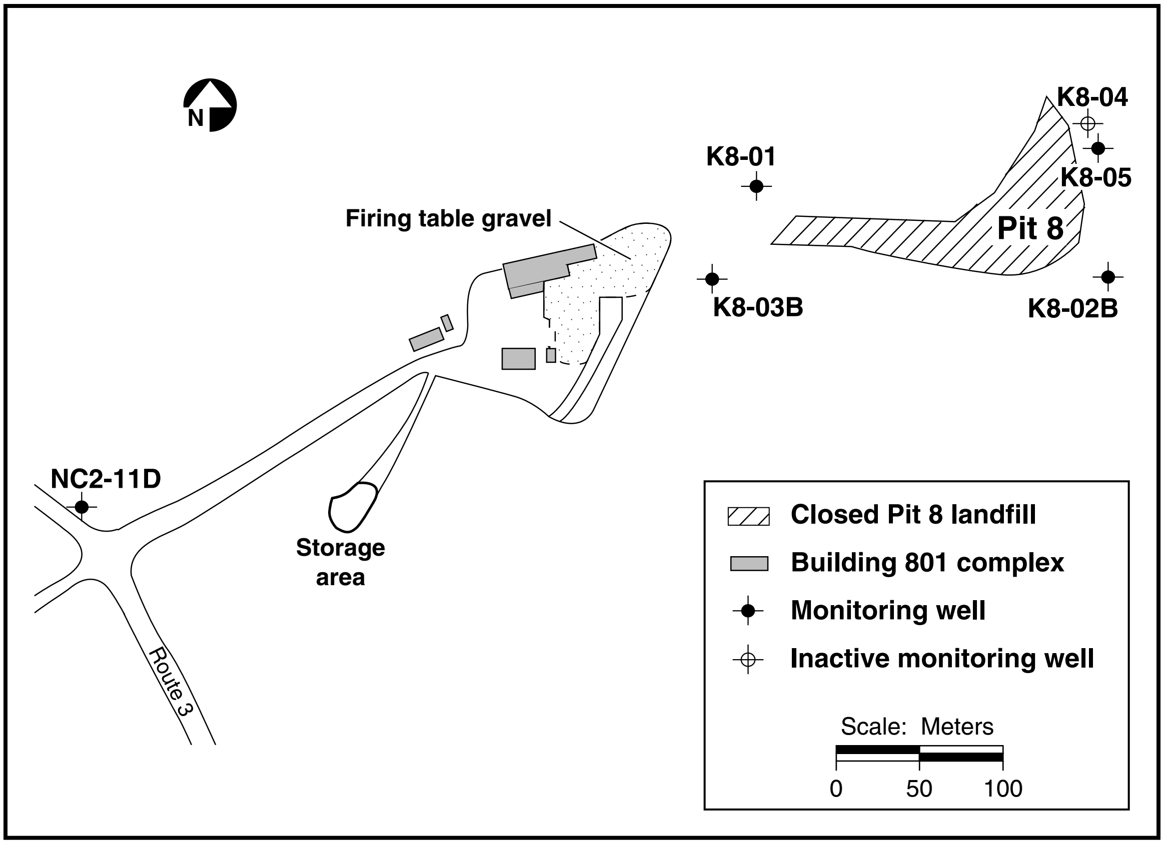


**Figure 9-6.** Locations of surveillance ground water monitoring wells, Pit 8, 1998.

Ground water samples from two monitoring wells, K8-01 and K8-02B, were analyzed once during 1998 for elements, nitrate, VOCs, explosive compounds, general radioactivity, tritium, and total uranium. The remaining wells were either dry or were inaccessible due to construction in this area.

### *Pit 9*

The Pit 9 landfill is centrally located within Site 300 about 340 m above sea level. Similar to the other closed landfills in Elk Ravine, the closed Pit 9 landfill contains firing table gravels with debris from explosives experiments at the adjacent Building 845 firing table. Surface runoff from Pit 9 is northward to the Elk Ravine arroyo.

**Figure 9-7** shows the locations of the four surveillance wells used to monitor the ground water in the vicinity of Pit 9. Ground water flows east-northeasterly beneath Pit 9 in the Neroly lower blue sandstone unit ($Tnbs_1$). The water table lies about 40 m below the ground surface at Pit 9. Monitoring well K9-02 is hydrologically upgradient from Pit 9, and wells K9-01, K9-03, and K9-04 are downgradient.

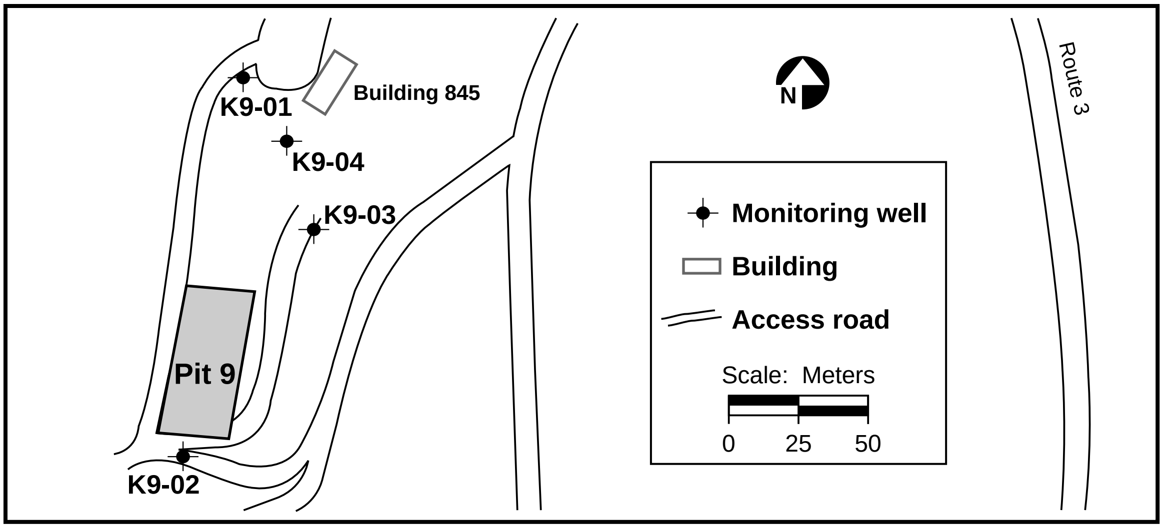


**Figure 9-7.** Locations of surveillance ground water monitoring wells, Pit 9, 1998.

The four Pit 9 monitoring wells were sampled once during 1998. The ground water samples were analyzed for 17 elements (mostly metals), nitrate, VOCs, energetic compounds, general radioactivity (gross alpha and gross beta), tritium, and total uranium.

### *Corral Hollow Creek Drainage Area*

#### *Pit 6*

Monitoring requirements for the closed Pit 6 landfill in the Corral Hollow Creek drainage area are specified in the *Post-Closure Plan for the Pit 6 Landfill Operable Unit Lawrence Livermore National Laboratory Site 300* (Ferry et al. 1998). The closed Pit 6 landfill covers an area of about 1 hectare (2.5 acres). Its elevation is approximately 215 m above sea level. From 1964 to 1973, approximately 1500 $m^3$ of solid wastes were buried there in nine separate trenches. The trenches were not lined, consistent with historical disposal practices. Three larger trenches contain 1300 $m^3$ of solid waste that includes empty drums, glove boxes, lumber, ducting, and capacitors. Six smaller trenches contain 230 $m^3$ of biomedical waste, including animal carcasses and animal waste. Minor releases of VOCs—primarily the solvent TCE, and tritium—occurred prior to closure. During 1997, a multilayered cap was constructed over all the trenches, and a drainage control system was installed around the cap. The cap and the drainage control system are engineered to keep rainwater from contacting the buried waste (Ferry et al. 1998).

The Pit 6 disposal trenches were constructed in Quaternary terrace deposits (Qt) above and north of the Corral Hollow Creek flood plain. Surface runoff from the pit area flows southward to Corral Hollow Creek. The Carnegie-Corral Hollow Fault zone extends beneath the southern third of Pit 6. The northern limit of the fault zone is shown in **Figure 9-8**. Beneath the northern two-thirds of Pit 6, ground water flows south-southeast, following the inclination (dip) of the underlying sedimentary rocks. Ground water seepage velocities are less than 10 m/y. Depths to the water table range from 10–20 m. Beneath the southern third of Pit 6, a trough containing terrace gravel within the fault zone provides a channel for ground water to flow southeast, parallel to the Site 300 boundary fence (Webster-Scholten 1994).

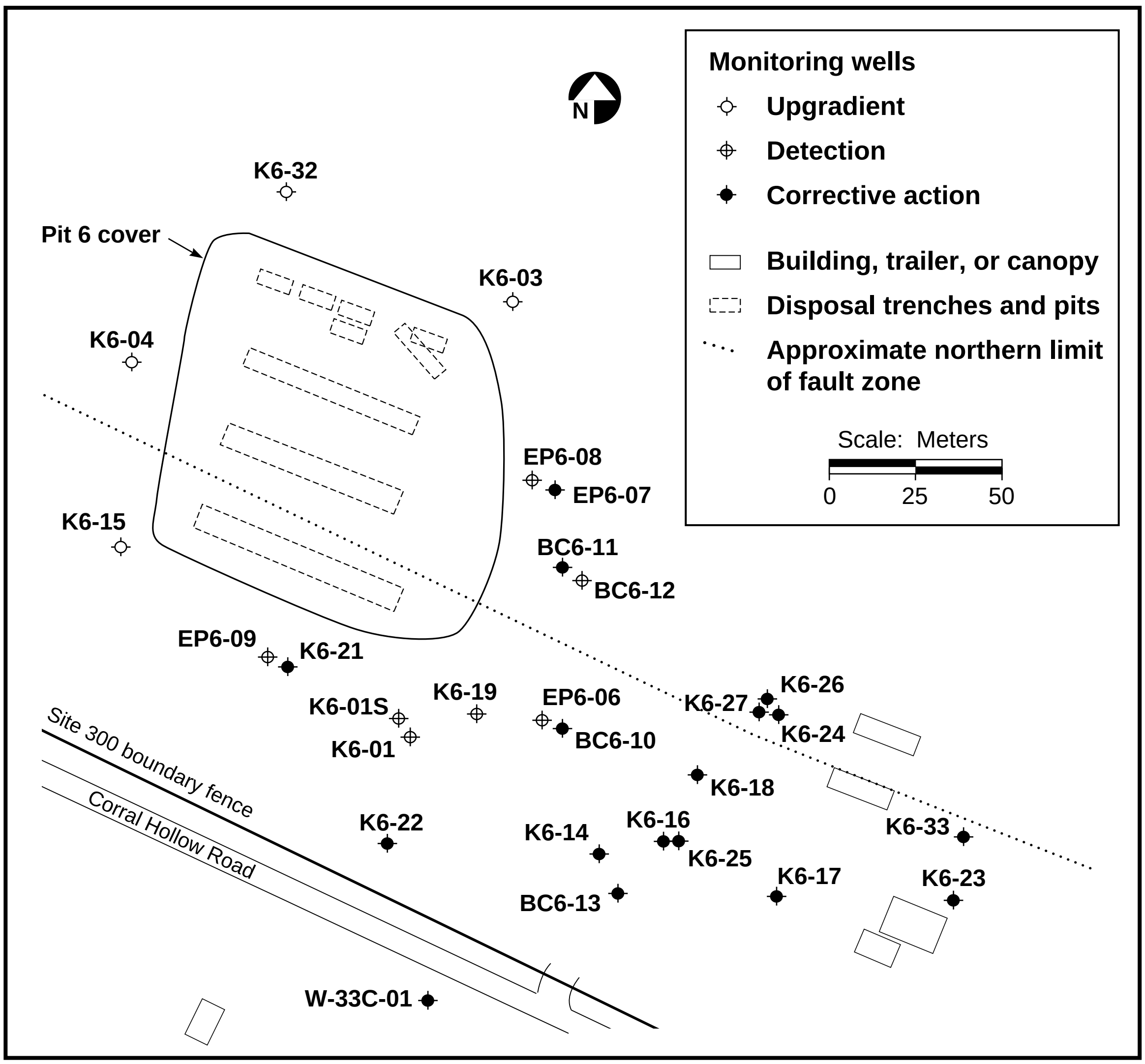


**Figure 9-8.** Locations of Pit 6 ground water monitoring wells.

Two new ground water monitoring programs were implemented at the Pit 6 landfill during 1998 to ensure compliance with all regulations. The Detection Monitoring Program (DMP) is designed to detect any new release of COCs to ground water from wastes buried in the Pit 6 landfill, while the Corrective Action Monitoring Program (CAMP), which operates under CERCLA, monitors the movement of existing releases (see Chapter 8 for a summary of CAMP monitoring results). Twenty-four COCs, including VOCs and radioisotopes, have been identified for monitoring in the ground water at Pit 6 (Ferry et al. 1998). **Figure 9-8** shows the locations of the wells used to monitor ground water in the vicinity of Pit 6.

Ground water at Pit 6 was sampled quarterly, beginning in the second quarter of 1998. Samples were measured for COCs required by the Pit 6 post-closure plan. Field measurements of ground water depth, temperature, pH, and specific conductance were obtained at each well at the time of sample collection. Two quarterly reports and one annual report covering monitoring activities at Pit 6 during 1998 have been published previously (Christofferson 1998a, 1998b; Christofferson and Taffet 1999).

### *Surface Impoundments*

WDR Order No. 96-248 establishes the basis for compliance monitoring of the two adjacent surface impoundments (see **Figure 9-9**). This includes quarterly monitoring of the ground water, monitoring of various influent waste streams to the surface impoundments, and visual observations of leachate collection and removal systems. Influent wastewater monitoring complements administrative controls that regulate the discharge of chemicals that could degrade the polyethylene liners of the impoundments. A three-tiered monitoring program comprising weekly visual inspections of the leachate collection and removal systems, quarterly inspections of lysimeters, and quarterly sampling of monitoring wells is in place to detect releases of chemicals from the surface impoundments in the Explosives Process Area.

As part of the Monitoring and Reporting Program (MRP) for the surface impoundments, contained in WDR 96-248, LLNL is required to obtain ground water samples quarterly from four monitoring wells (see **Figure 9-9**) and establishes statistical concentration limits for COCs in ground water beneath the surface impoundments.

WDR 96-248 establishes limits for discharges of COCs into the surface impoundments and requires monitoring of the photographic process and chemistry area wastewater retention tanks that discharge to the surface impoundments as well as direct discharges to the surface impoundments from explosives processing. Influent streams are monitored at a prescribed frequency for area-specific COCs.

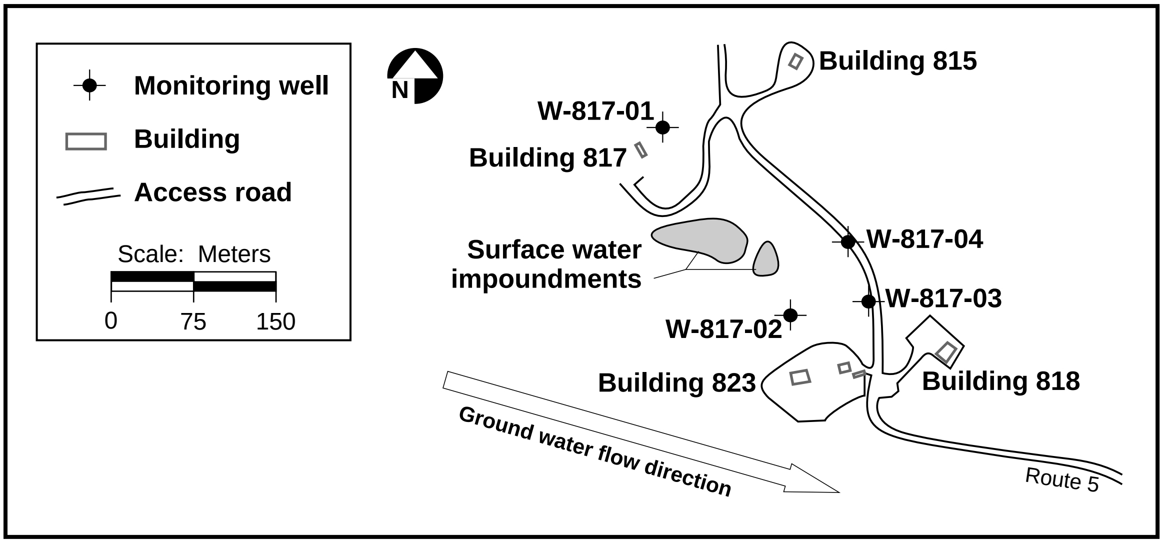


**Figure 9-9.** Locations of compliance ground water monitoring wells in the Explosives Process Area.

Retention tanks containing photographic process rinsewater from Buildings 801, 823, 850, and 851 are sampled to confirm that discharges are consistent with COC limits specified in WDR 96-248. Discharges to the surface impoundments occur after samples are obtained, except for rinsewater from the Building 823 retention tanks, which is discharged automatically to the surface impoundments and sampled quarterly.

Wastewater from the Chemistry Area (Buildings 825, 826, and 827 complex) is held in retention tanks until analytical results indicate compliance with WDR 96-248.

Process water discharges to the surface impoundments are analyzed for COCs that have been found (or are likely to be found) in the process water from each specified building within the Explosives Process Area. This monitoring program includes process area wastewater from Buildings 806/807, 809, and 817. WDR 96-248 requires annual analysis of this waste stream at Buildings 806/807, 809, and 817.

### *Percolation Pits*

Percolation pits that are designed to accept discharges from mechanical equipment are located at Site 300 Buildings 806A, 827A, 827C, 827D, and 827E. In other remote Site 300 facilities, these types of waste streams are discharged to septic systems. This discharge is permitted by WDR 96-248. WDR 96-248 specifies monthly observations and monitoring requirements for overflows. Overflows of the percolation pits, should they occur, are sampled and analyzed for metals.

### *Sewage Evaporation and Percolation Ponds*

Site 300 is not serviced by a publicly owned treatment works (POTW) as is the Livermore site; therefore, alternate methods of treating and disposing of sanitary waste are necessary. Sewage generated at buildings in the General Services Area is discharged into a lined evaporation pond. Most of the time, the wastewater evaporates from the sewage evaporation pond; however, during periods of high rainfall, treated wastewater may overflow into a connected percolation pond, where it enters the ground.

The environmental monitoring requirements for the sewage evaporation and percolation ponds (hereafter sewage ponds) are specified in the MRP 96-248 contained in WDR 96-248. The monitoring requirements include both wastewater monitoring and monitoring of the ground water to detect potential impacts of the sewage on ground water quality.

Wastewater is sampled quarterly at an influent location (ISWP) and within the pond (ESWP). Overflows are sampled as needed at location (DSWP). The sampling locations are shown in **Figure 9-10**.

Nine ground water monitoring wells are sampled semiannually to provide information on the ground water quality in the vicinity of the sewage ponds (**Figure 9-10**). The wells are screened in three different geological formations (Qal, $Tnbs_{1}$, and $Tnsc_{1}$). $Tnbs_{1}$ (Neroly Formation lower blue sandstone unit) is the regional aquifer.

## Sampling and Analytical Methods

Representative samples of ground water from monitoring wells were obtained in accordance with the *LLNL Livermore Site and Site 300 Environmental Restoration Project Standard Operating Procedures (SOPs)* (Dibley and Depue 1998). The protocols cover sampling techniques and specific information for the analytes that are routinely searched for in ground water.

Different sampling techniques were applied to different wells depending on whether they were fitted with submersible pumps, had to be bailed, or contained Barcad devices. See the Data Supplement for sampling details.

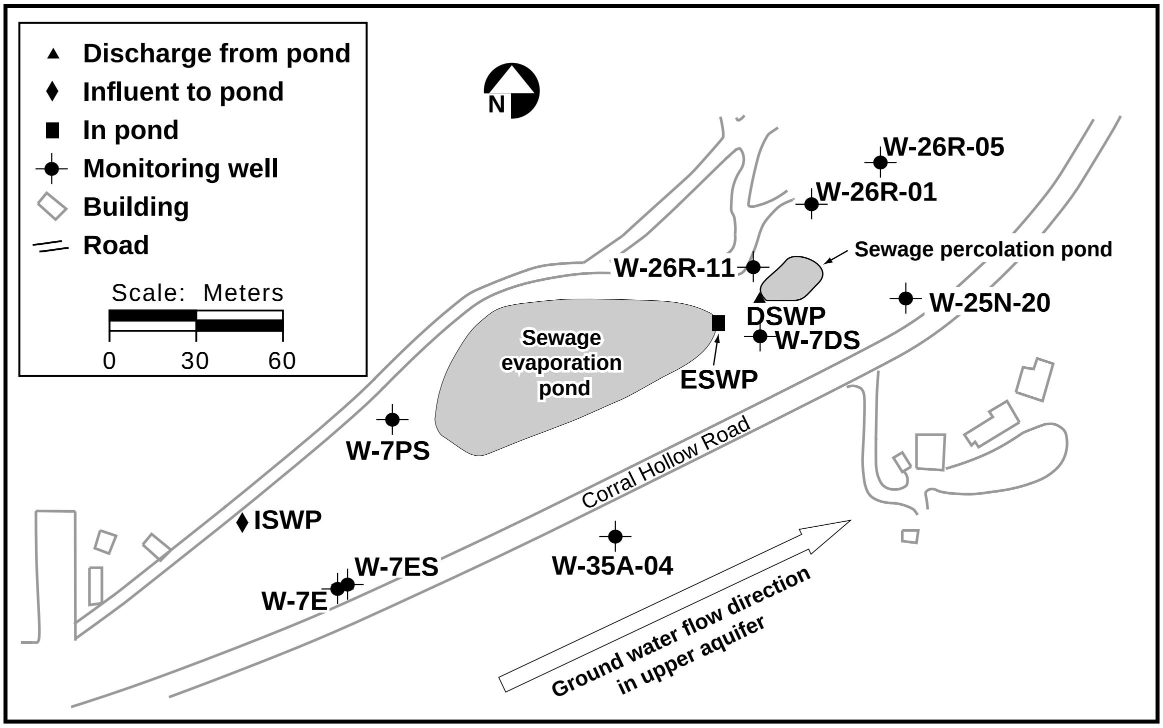


**Figure 9-10.** Sewage evaporation and percolation ponds, compliance ground water monitoring wells, and wastewater monitoring locations.

At Site 300, wastewater samples from the photographic and explosives process areas, sewage evaporation pond influent, water in the pond, and overflow water from percolation pits pond were obtained in accordance with the standardized procedures of the Operations and Regulatory Affairs Division (Tate et al. 1995). Standard sample handling and hygiene procedures were employed to prevent cross-contamination (e.g., wearing disposable gloves, decontaminating equipment between use, and maintaining samples at 4 ± 2°C). Replicates, field blanks, and trip blanks were obtained for quality assurance/quality control purposes. Analyses were performed by state-certified contract analytical laboratories.

Technologists collected wastewater samples from retention tanks in the Chemistry Area associated with Buildings 825, 826, and 827 using Hazardous Waste Management Procedure 411. Wastewater was held in retention tanks until analytical results were reviewed for compliance with WDR No. 96-248. Most of the analyses were performed by LLNL, which is state-certified for some analyses. Some analyses were done by off-site contract laboratories late in the year.

Table 9-19 in the Data Supplement shows the analytical methods and reporting limits for inorganic constituents (including specific radioisotopes analyzed by alpha spectroscopy and other sensitive methods), organic constituents, and radioisotopes in ground water.

## Results

This section presents the monitoring results for the Livermore site and environs as well as Site 300.

### *Livermore Site and Environs*

#### *Livermore Valley*

Measurements of water samples obtained during the summer of 1998 from 20 wells in the Livermore Valley show very low tritium levels compared with the 740 Bq/L (20,000 pCi/L) maximum contaminant level (MCL) established by the State of California. The highest tritium activity measured off site was 9.03 Bq/L in a ground water sample from well 12D2, (see **Figure 9-1**), located about 10 km west of LLNL (results are reported in Data Supplement Table 9-20).

Tritium activity has been decreasing in Livermore Valley ground waters downgradient of LLNL. The median activities of tritium in ground water samples from these downgradient wells decreased from 4.59 Bq/L in 1989 to –0.044 Bq/L in 1998 based on the three positive detections of tritium and 17 calculated values.

#### *Livermore Site Perimeter*

Tritium activity ranged from –1.29 to 5.66 Bq/L in ground water samples from on-site upgradient monitoring wells and from 0.15 to 11.1 Bq/L in perimeter downgradient monitoring wells.

Bromacil, a herbicide, was detected in June 1998 in off-site surveillance well W-151 at 3.6 µg/L (see Data Supplement Table 9-6). Although there is no drinking water MCL for bromacil, the EPA has determined that concentrations of bromacil greater than 90 µg/L could be hazardous to human health. Bromacil above the reporting limit (0.5 µg/L) or any other herbicides were not detected in later samplings of W-151 in August and October. Herbicides detected in the ground water probably result from runoff through stream channels, including arroyos. (See Chapter 7 for storm water runoff results.) No herbicides were detected in the upgradient monitoring wells, W-008 and W-221 during 1998 (see Data Supplement Tables 9-1 and 9-2).

The inorganic compounds detected, including dissolved trace metals and minerals, occur naturally in the ground water at variable concentrations. **Table 9-1** shows the three anions with the highest concentrations in the two upgradient wells and the seven downgradient wells at LLNL. Concentrations of these major anions are higher in the upgradient wells than in the downgradient wells. (See Tables 9-1 through 9-9 in the Data Supplement.) The boron concentration of 9.1 mg/L in upgradient monitoring well W-008 in February 1998 is an order of magnitude higher than the downgradient wells. Poor ground water quality in the upgradient portions of the site has been described previously (Thorpe et al. 1990).

**Table 9-1.** Concentration ranges for three major anions in upgradient and downgradient monitoring wells.

| Flow | Concentration range (mg/L) | | | | | |
|---|---|---|---|---|---|---|
| | Bicarbonate ($HCO_3^-$) | | Chloride ($Cl^-$) | | Sulfate ($SO_4^{2-}$) | |
| | Range | Median | Range | Median | Range | Median |
| Upgradient | 229–356 | 289 | 284–526 | 392 | 84–326 | 204 |
| Downgradient | 193–292 | 243 | 78–131 | 86 | 27–69 | 40 |

In 1996, nitrate was detected at concentrations greater than the MCL of 45 mg/L in ground water samples obtained from monitoring well W-1012 (screened in HSU 2). In 1998, the concentration of nitrate for this well was 78 mg/L (see Data Supplement Table 9-4). This is the highest nitrate concentration measured in any on-site monitoring well during 1998. The highest concentration measured in an off-site well was 39 mg/L, in monitoring well W-151 (see Data Supplement Table 9-6). The nitrate may originate as an agricultural residue (Thorpe et al. 1990).

Aluminum, antimony, arsenic, cadmium, cobalt, manganese, mercury, molybdenum, silver, thallium, and vanadium were not detected in concentrations above laboratory reporting limits during 1998 in any of the Livermore site perimeter downgradient monitoring wells. Vanadium was detected in both upgradient wells, W-008 and W-221 (see Data Supplement Tables 9-1 and 9-2), and arsenic was detected in upgradient well W-008. Lead was detected once in downgradient monitoring well W-571 at a concentration of 5.3 µg/L in a third quarter ground water sample (see Data Supplement Table 9-9). This concentration is below the EPA's Action Level of 15 µg/L for lead. Beryllium was detected once at 0.7 µg/L in a ground water sample obtained from off-site downgradient well W-151. The drinking water MCL for beryllium is 4 µg/L (see Data Supplement Table 9-6).

None of the ground water samples obtained from surveillance monitoring wells during 1998 had concentrations of radioisotopes or radioactivity that exceeded a drinking water MCL. The highest tritium activity measured in a ground water sample was 11.1 Bq/L, equal to 1.5% of the tritium MCL. The sample was from monitoring well W-373 (see Data Supplement Table 9-7).

As in the past, concentrations of uranium continue to be highest in the upgradient wells W-008 and W-221. Concentrations of U-234 in those wells range from 0.107 to 0.202 Bq/L; concentrations of U-238 range from 0.0685 to 0.179 Bq/L (see Data Supplement Tables 9-1 and 9-2). Activities of U-234 and U-238 are lower in ground water from each of the perimeter downgradient wells. Uranium and its radioactive daughters, Th-230 and Ra-226, occur naturally in the sediments and rock layers beneath and surrounding LLNL. Uranium activities did not exceed drinking water limits. Other monitored radioisotopes were below detection limits in the ground water samples.

### *Livermore Site*

Atrazine, an herbicide, was detected at a concentration of 0.35 µg/L in a June 1998 ground water sample obtained from well W-593 in the northeastern portion of the site (see **Figure 9-2**) (see Table 9-17 in the Data Supplement). A very low concentration (0.33 µg/L) of atrazine was also detected in this well in December 1997. The California and federal drinking water MCL for atrazine is 3 µg/L. The concentration of atrazine measured is 12% of the MCL.

Ground water downgradient showed some impact from two releases of metals to ground. Ground water at well W-307 near Building 322 showed the presence of beryllium (1.7 µg/L) and copper (6.8 µg/L) (see Data Supplement Table 9-18). Background concentrations, from upgradient wells W-008 and W-221, are <0.2 µg/L for beryllium and 3.4 µg/L or less for copper (see Data Supplement Tables 9-1 and 9-2). Chromium and copper were detected at elevated concentrations in ground water samples from wells W-226 and W-306, downgradient from the Building 253 catch basin. Chromium concentrations were 25 µg/L (well W-226) and 38 µg/L (well W-306); copper concentrations were 14 µg/L (well W-226) and 30 µg/L (well W-306) (see the Data Supplement, Table 9-18). The accumulated sediment in the catch basin is a potential source of chromium and copper. No measured concentration exceeded an MCL for drinking water.

## Site 300

The following summaries of analytical results for 1998 briefly discuss compliance monitoring results for Site 300 that exceed permitted concentration limits, i.e., statistical limits (SLs), or otherwise suggest that a release of a COC to ground water has occurred. Monitoring data and analyses were published quarterly for 1998 (Christofferson 1998a and b; Christofferson and MacQueen 1998a, b, c, and 1999; Christofferson and Taffet 1999).

### Elk Ravine Drainage Area

#### Pit 7

Analytical results for the Pit 7 compliance ground water monitoring network for 1998 are presented in Data Supplement Tables 9-21 and 9-22. Third quarter total uranium activity exceeded the statistical limit of 2.33 Bq/L in ground water at monitoring well NC7-48 (2.59 Bq/L), and LLNL notified the CVRWQCB by letter of this finding, which constituted statistically significant evidence of a uranium release (Galles 1998a). Depleted uranium was probably released to ground water from Pit 7 for a period of several months during 1998. Ground water may have risen into Pit 7 and dissolved some depleted uranium buried there. The change in ground water depth was the result of considerable local recharge from 58 cm of rainfall during the El Niño winter rainy season of 1997–1998 (mean total annual Site 300 rainfall is 27 cm). Nearby Pits 3 and 5 are known to have been partially inundated by rising ground water during February 1998 (Ziagos and Reber-Cox 1998b). Three small ground water plumes contain depleted uranium released from Pit 5, Pit 7, and the Building 850 firing table area (Taffet et al. 1996). The maximum uranium activity detected is 4.4 Bq/L, which represents the sum of depleted uranium and naturally occurring uranium. Uranium activity in ground water at well NC7-48 decreased to 0.895 Bq/L during the fourth quarter, suggesting that the release from Pit 7 was short lived and ceased during the latter part of the year when ground water levels fell (Christofferson and MacQueen 1999).

Tritium activity increased in ground water at the Pit 7 downgradient monitoring well NC7-25, and it reached 24,500 Bq/L in November, 33 times the MCL of 740 Bq/L. LLNL CERCLA remedial investigations link the increased activity to slug releases of tritium from Pit 3, beginning during the winter of 1992–93, and continuing during successive winters of 1994–95, 1995–96, 1996–97, and 1997–98 (El Niño winter), when Pit 3 was partially inundated by rising ground water (Taffet et al. 1996, Ziagos and Reber-Cox 1998b). The releases have produced elevated tritium activity in the ground water adjacent to Pit 3 that extends to monitoring well NC7-25. Modeling indicates that, given tritium's short half-life of 12.3 years and the relatively slow rate of ground water movement, the activity of the released tritium in ground water will decrease to below the MCL before it can travel off site (Taffet et al. 1996).

As in the past, the VOC trichlorofluoromethane (Freon 11) was detected each quarter in the ground water at Pit 7 monitoring well NC7-48. Concentrations ranged from 0.77 to 1.2 µg/L, far below the MCL of 150 µg/L. Pit 7 is the likely source of the Freon 11, because it is the only landfill upgradient of well NC7-48.

### *Elk Ravine*

Analytical results for the Elk Ravine drainage area surveillance monitoring network are presented in Data Supplement Table 9-23. Generally, surveillance monitoring of Elk Ravine during 1998 showed no evidence of any new release of COCs to ground water in this area. As in past years, arsenic, barium, chromium, lead, selenium, vanadium, and zinc were detected at low concentrations typical of ground water in the Altamont Hills. No measurement was above a drinking water MCL. Nitrate was detected in all Elk Ravine ground water samples, except those from well NC7-69 that monitors a deeper water-bearing zone. Nitrate appears primarily in the uppermost water-bearing zone and was measured above the MCL of 45 mg/L in ground water at monitoring wells NC7-61 (97mg/L and 66 mg/L), K2-04S (58 mg/L and 51 mg/L), and K2-01C (48 mg/L).

No energetic compounds were detected. Gross alpha and beta activities were low and indistinguishable from background, as was total uranium activity. Tritium activity was above background in many ground water samples.

Tritium, as tritiated water (HTO), has been released in the past from the Pit 3 and 5 landfills and from beneath the firing table at Building 850. Tritiated water was released from Pit 3 and Pit 5 during wetter-than-normal winters when ground water rose and contacted buried firing table wastes. The wet El Niño winter of 1997/1998 caused ground water to rise significantly into Pits 3 and 5, releasing more HTO (Ziagos and Reber-Cox 1998b). HTO was transported to ground water beneath the Building 850 firing table gravels by percolating rainwater (Taffet et al. 1996). The configuration of the commingling HTO plumes at Site 300, updated for 1998, are shown in Chapter 8, **Figure 8-1**. The plumes are shallow and appear to be confined to the Neroly lower blue sandstone unit ($Tnbs_1$ and Qal). Tritium activity was not discernible in ground water samples from the deeper water-bearing zone monitored at well NC7-69 that is screened in the Cierbo (Tmss) Formation, beneath $Tnbs_1$.

The majority of the Elk Ravine surveillance network tritium measurements made during 1998 support CERCLA studies, which show that, despite additional releases, the tritium contents and extents of the plumes are generally diminishing over time because of natural decay and dispersive mixing (Ziagos and Reber-Cox 1998b). We observe small increases in tritium activity near the sources (well K7-07) and at the distal end of the plume (wells K2-01C, NC2-11D, and NC2-12D), while those wells monitoring the bulk of the plume (NC7-61, K2-04D, and K2-04S) show relatively large decreases in tritium activity over the past several years. For example, tritium activity in ground water at well NC7-61 decreased from 6500 Bq/L in 1996 to 4500 Bq/L in 1998.

### *Pit 2*

No release of a COC from Pit 2 to ground water is indicated by the surveillance monitoring data obtained during 1998. Analytical results for the Pit 2 surveillance monitoring network are presented in Data Supplement Table 9-24. Several metals were detected at low concentrations. Most were below analytical reporting limits, which are in the parts per billion (ppb) range. None exceeded an MCL. Arsenic and barium concentrations measured within the range of natural (background) concentrations in ground waters at Site 300 (Webster-Scholten 1994).

The radioactivity and radioisotope measurements show only low background activities for gross alpha and gross beta. Tritium activities were all low except for the intermediate water-bearing zone sampled by Barcad K2-01B (9.4 Bq/L) (**Figure 9-5**). This activity is associated indirectly with the plume of tritium-bearing water from the Building 850 firing table (see Chapter 8, **Figure 8-16**) (Webster-Scholten 1994; Taffet et al. 1996). The incursion of shallow, tritium-bearing ground water into the Pit 2 area is recorded in ground water samples from surveillance well K2-01C that showed a tritium activity of about 600 Bq/L during 1998 (see Elk Ravine Drainage Area). The trace of tritium detected in the K1-02B sample suggests that the shallow and intermediate-depth water-bearing zones are weakly connected, perhaps along the nearby Elk Ravine fault.

### *Pit 1*

No release of a COC to ground water from Pit 1 is indicated by the compliance monitoring data obtained during 1998. Analytical results for the Pit 1 compliance ground water monitoring network for 1998 are presented in Data Supplement Tables 9-25 and 9-26. Fourth quarter tritium activity exceeded the statistical limit of 23.4 Bq/L in the ground water at Pit 1 monitoring well K1-03 (25.1 Bq/L), and LLNL notified the CVRWQCB by letter of this finding, which constituted statistically significant evidence of a tritium release from Pit 1 (Galles 1999). However, previous CERCLA studies indicate that the tritium activity seen in ground water at several Pit 1 monitoring wells most likely comes from the Building 850 firing table, located about 1 km west and upgradient of Pit 1 (Webster-Scholten 1994, Taffet et al. 1996, Ziagos and Reber-Cox 1998b; see the tritium plume in Chapter 8, **Figure 8-16**).

Also from a source outside of Pit 1, the VOC 1,1,2-trichloro-1,2,2-trifluoroethane (Freon 113) was detected during the fourth quarter in ground water at monitoring wells K1-05 (40 µg/L), K1-08 (65 µg/L), and K1-09 (140 µg/L). The results are all far below the MCL of 1200 µg/L for this VOC. Previous CERCLA studies link the VOC to past spills in the Advanced Test Accelerator area (**Figure 9-5**), about 200 m west and upgradient of the affected wells (Webster-Scholten 1994b; Taffet et al. 1996).

#### *Pit 8*

No release of a COC to ground water from Pit 8 is indicated by the surveillance monitoring data obtained during 1998. Analytical results for the Pit 8 surveillance monitoring network are presented in Data Supplement Table 9-27. Two VOCs, TCE and 1,2-DCA, were detected below their 5 µg/L MCLs. Although only two monitoring wells could be sampled, the upgradient well, K8-01, contained the higher concentrations. The VOC TCE was detected in ground water at upgradient well K8-01 (2.8 µg/L) and at downgradient well K8-02B contained 1.3 µg/L). The ground water at upgradient well K8-01 contained 1.1 µg/L 1,2-DCA. A relatively small VOC plume exists beneath this area (see Chapter 8, **Figure 8-11**), which is believed to have originated before 1981 in wastes discharged to a dry well upgradient from Pit 8, near Building 801 (Webster-Scholten 1994).

Arsenic, chromium, and selenium were detected in concentrations below their MCLs, and similar to their natural concentrations in ground water in the Altamont Hills. As in the past, nitrate was detected above the MCL of 45 mg/L in the upgradient ground water at well K8-01 (47 mg/L). The origin of the nitrate is presently unknown. A CERCLA study of nitrate provenance in ground water at Site 300 was begun in 1998.

#### *Pit 9*

Analytical results for the Pit 9 surveillance monitoring network are presented in Data Supplement Table 9-28. COCs were either not detected or were indistinguishable from natural background concentrations during 1998 sampling. No evidence for a release from Pit 9 is indicated by the surveillance monitoring data obtained during 1998.

### *Corral Hollow Creek Drainage Area*

#### *Pit 6*

Analytical results for the Pit 6 DMP ground water compliance monitoring network for 1998 are presented in Data Supplement Tables 9-29 and 9-30. Two COCs, tritium at well K6-19 and 1,2-dichloroethane (1,2-DCA) at well EP6-09, both measured above their respective statistical limits during 1998. Most likely, they were released from Pit 6, but the timing of their release is not known. Ground water at well EP6-09 contained

0.68 µg/L and 0.52 µg/L of 1,2-DCA during the third and fourth quarters, respectively. 1,2-DCA was not detected in ground water at any other Pit 6 monitoring wells during 1998. The measured concentrations of 1,2-DCA slightly exceeded the 0.5 µg/L MCL, and LLNL notified the CVRWQCB by letter of this finding, which constituted statistically significant evidence of a release of 1,2-DCA from Pit 6 (Galles 1998b).

LLNL notified Site 300 Remedial Program Managers (RPMs) prior to the implementation of post-closure monitoring regarding a potential tritium release from Pit 6. The RPMs requested that further CERCLA studies be made to determine the source of the tritium. The highest tritium activity measured during 1998 was 91 Bq/L in ground water at monitoring well K6-19. The highest measured activity is 12% of the MCL of 740 Bq/L for tritium in drinking water.

The compound bis(2-ethylhexyl)phthalate, which had not been detected in ground water at Pit 6 since 1984, was detected in ground water at three wells (K6-04, EP6-06, and EP6-08) during the second quarter of 1998, in one well (EP6-08) during the third quarter, and it was absent from all wells during the fourth quarter. Concentrations ranged from 5.4 µg/L to 41 µg/L, considerably above the 4 µg/L MCL set for this chemical. The chemical was used in explosives experiments at Site 300.

### *Surface Impoundments*

The two leachate collection and removal systems were monitored weekly for the presence of liquids. In 1998, no water was recovered from the leachate collection and removal system. The visual inspections indicate that the impoundment liners did not leak wastewater during 1998. No water has been observed in the leachate collection and removal system since liner repairs were made in 1997. No water was found in five lysimeters, which also indicates that the impoundment liners did not leak wastewater during 1998. Analytical results for COCs in Site 300 ground water beneath the surface impoundments are listed in Data Supplement Tables 9-31, 9-33, 9-35, and 9-37.

The explosive compounds (HMX, RDX, and TNT) and perchlorate are the compounds most indicative of discharges to ground water from the Explosives Process Area surface impoundments. However, prior to 1985 explosives wastewater was discharged into unlined ponds in the vicinity of the surface impoundments, where it infiltrated the soil and some reached ground water. Because of this past practice, care must be exercised to discriminate between new releases from the surface impoundments and past releases from the unlined ponds. Analyses of ground water from upgradient monitoring well W-817-01 during 1998 show HMX concentrations between 15.0 and 17.5 µg/L. HMX was not detected above the analytical reporting limit of 1.0 to 2.5 µg/L in any of the ground water samples from the downgradient monitoring wells. Ground water samples from three wells contained detectable concentrations of the explosive compound RDX above the analytical reporting limit of 0.85 µg/L. The ground water samples containing RDX were from upgradient well W-817-01 (from 44.2 to 58.3 µg/L) and from downgradient wells W-817-03 (5.68 to 8.10 µg/L) and W-817-04 (2.71 to 5.28 µg/L). The RDX and HMX originated at closed disposal sites upgradient of the present surface impoundments (Raber and Carpenter 1983, Webster-Scholten 1994). Also, 4-amino-2,6-dinitrotoluene, a breakdown product, was detected in upgradient well W-817-01 (<2.2 to 11 µg/L), and in downgradient wells W-817-03 (<0.26 to 0.64 µg/L) and W-817-04 (0.264 to 0.556 µg/L). The concentrations observed in the downgradient wells do not exceed their statistical limits. Additional compounds were detected by EPA Method 8330 but do not have statistical limits or MCLs and are presented in Data Supplement Tables 9-32, 9-34, 9-36, and 9-38. The source for these compounds is upgradient from the surface impoundments because the highest concentrations are detected in the upgradient ground water.

LLNL began monitoring ground water for perchlorate in 1998, soon after the California Department of Health Services approved an analytical method (EPA Method 300.0-IC). Ammonium perchlorate is one of the compounds potentially being discharged into the surface impoundments. Perchlorate was detected quarterly in the ground water beneath the surface impoundments during 1998 (Brown, Mathews, and Ward 1998a, b, and 1999). A CERCLA characterization of perchlorate in Site 300 ground water was begun in 1998 (see Chapter 8). Analytical results for perchlorate were highest (0.012 to 0.050 mg/L) in samples obtained from monitoring well W-817-01, which is upgradient of the surface impoundments. Perchlorate was also detected in samples from the downgradient wells W-817-02 (<0.004 to 0.032 mg/L), W-817-03 (0.005 to 0.032 mg/L), and W-817-04 (0.011 to 0.029 mg/L). The California Department of Health Services has developed a regulatory action level of 0.018 mg/L for perchlorate.

TCE in the ground water exceeded the drinking water MCL of 5 µg/L in samples from wells W-817-03 and W-817-04 during 1998. The TCE has migrated from past spills at Building 815, upgradient of the impoundments (Webster-Scholten 1994). TCE is not discharged to the surface impoundments (see also Chapter 8).

As in the past, ground water concentrations of arsenic and nitrate continued to exceed drinking water MCLs in ground water samples from all the surface impoundment monitoring wells during 1998. Concentrations of both arsenic and nitrate in ground water have historically exceeded their respective MCLs (0.050 mg/L for arsenic and 45 mg/L for nitrate) in this area. Background concentrations of arsenic in ground water monitoring wells upgradient from the surface impoundments have been measured at concentrations above the drinking water MCL (Webster-Scholten 1994). Although the distribution of arsenic over time and throughout the area suggests a natural source, the occurrence and concentration of arsenic at Site 300 is the subject of a continuing

CERCLA study. Analytical results for the WDR 96-248 ground water COCs, are in Data Supplement Tables 9-31, 9-33, 9-35, and 9-37.

During 1998, all discharges into the surface impoundments were in compliance with discharge concentration limits (see Data Supplement Tables 9-39 through 9-43). An overflow of the Building 825 retention tank and secondary containment system occurred on February 3, 1998, as a result of heavy rain. A representative water sample was obtained and analyzed for COCs. The data were reported and showed no COC concentrations above permitted limits (Mathews and Brown 1998). Because all 1998 discharges were in compliance with WDR 96-248, the polyethylene liners were not subject to chemical degradation.

### *Percolation Pits*

During 1998, the percolation pits at Building 806A, 827D, and 827E operated normally; no standing water was noted during monthly inspections and no overflows occurred. Standing water was noted in the Building 827C percolation pit during the first and fourth quarters, and the pit overflowed during the second quarter. A sample for metals analysis was collected from the overflow water. Seven metals were detected above the analytical reporting limit: boron, total chromium, chromium(VI), copper, iron, lead, and zinc (see Data Supplement Table 9-44). However, the chromium(VI) result exceeded the concentration of total chromium in the sample and is considered invalid.

### *Water Supply Wells*

Analytical results for Site 300 water supply Wells 18 and 20 are presented in Data Supplement Tables 9-45 and 9-46. Barium (62 µg/L) and copper (11 µg/L) were detected once in well 20 water samples during 1998 at concentrations far below their MCLs of 1000 µg/L. As in past years, TCE was detected below the MCL of 5 µg/L in ground water samples from well 18 (0.32, 0.29, and 0.25 µg/L). The source of the TCE has not yet been identified. Gross alpha, gross beta, and tritium activities in water samples from both production wells are very low and are indistinguishable from natural background activities.

### *Sewage Evaporation and Percolation Ponds*

All wastewater parameters for the sewage evaporation and percolation ponds complied with permitted limits throughout 1998. Analytical results are presented in **Tables 9-2** and **9-3**. No samples were obtained from the percolation pond (location DSWP) during 1998 because there were no discharges from the evaporation pond into the percolation pond.

**Table 9-2.** Sewage pond monitoring results, location ESWP.

| Parameter | Permit limits | First quarter | Second quarter | Third quarter | Fourth quarter |
|---|---|---|---|---|---|
| pH (pH units) | none | 9.7 | 9.5 | 9.6 | 9.5 |
| Conductivity (µmho/cm) | none | 550 | 5700 | 7200 | 10,000 |
| Dissolved oxygen (mg/L) | 1.0 | 12 | 9.2 | 3.9 | 28 |
| **Nutrients (mg/L)** | | | | | |
| Ammonia nitrogen (as N) | none | NS | NS | 0.3 | 0.2 |
| Nitrate (as N) | none | NS | NS | <0.1 | <1 |
| Nitrate (as $NO_3$) | none | <0.4 | <0.4 | <0.4 | <4.4 |
| Nitrite (as N) | none | NS | NS | 0.2 | <0.2 |
| Nitrite (as $NO_2$) | none | NS | NS | <0.7 | <0.66 |
| Total Kjeldahl nitrogen | none | NS | NS | 13 | 54 |

NS = Not sampled. Nutrient sampling is part of a special study that began in the third quarter.

**Table 9-3.** Wastewater effluent monitoring results, location ISWP.

| Parameter | Permit limits | First quarter | Second quarter | Third quarter | Fourth quarter |
|---|---|---|---|---|---|
| pH (pH units) | 6.5 < pH < 10 | 8.8 | 8.6 | 8.8 | 6.8 |
| Conductivity (µmho/cm) | none | 1400 | 1800 | 1700 | 1600 |
| Biochemical oxygen demand (mg/L) | none | 93 | 120 | 290 | 2100 |

As a result of heavy rains in January 1998, LLNL received permission from the CVRWQCB in February to operate the sewage evaporation pond with less than the required freeboard of 0.61 m (2 ft). The sewage evaporation pond operated with less than the required freeboard from February 18 to June 22, 1998. All other observations—levee condition, color, and odor—indicated normal operations.

The ground water analytical data for the sewage pond monitoring network are presented in Data Supplement Tables 9-47 and 9-48. All of the monitored constituents were in compliance with permitted limits. Nitrate increased in downgradient monitoring wells W-26R-01 and W-26R-05 to 40 and 53 mg/L, respectively, during the third quarter. LLNL is currently undertaking studies to determine the origin of this nitrate, including a special study of nitrate and other nutrients in the sewage evaporation pond. This study will continue into 1999. Analyses obtained during 1998 as part of this study are reported in **Table 9-2** (location ESWP).

### *Off-Site Water Supply Wells*

Analytical results for the off-site water supply wells are presented in Data Supplement Tables 9-49 to 9-54. Generally, no COC attributable to LLNL activities was detected in the off-site ground water samples. Arsenic and barium were widely detected at these locations, but their concentrations were below MCLs and consistent with natural sources in the rocks. Scattered detections of metals were all below MCLs and were probably related to metals used in pumps and supply piping.

As in past years, TCE was detected below the MCL of 5 µg/L in the ground water samples obtained from well GALLO1 (0.31 µg/L) during the fourth quarter. LLNL CERCLA investigators previously concluded that the low concentration of TCE in the GALLO1 well water was probably because of a localized surface spill on the property, possibly from solvents used on a pump truck or another vehicle used to service the private well (Webster-Scholten 1994). (Monitoring of a similarly sited well, GALLO2, had to be terminated several years ago because of contamination from chemicals leaking from the pumping apparatus.) Radioactivity measurements of off-site ground water are all indistinguishable from natural background activities.

## Environmental Impacts

The overall impact of LLNL Livermore site and Site 300 operations on off-site ground waters is minimal. With the exception of VOCs being remediated under CERCLA at both sites, LLNL operations have little or no adverse effect on the surrounding ground waters.

### *Livermore Site and Environs*

Ground water monitoring at the LLNL Livermore site and in the Livermore Valley indicates that LLNL operations, both past and present, have minimal impact on ground water beyond the site boundary. (See Chapter 8 for CERCLA remediation activities with VOCs.) During 1998, neither radioactivity nor concentrations of elements or compounds detected in ground water from any off-site monitoring well exceeded primary drinking water MCLs. The maximum tritium activity of 11.1 Bq/L (301 pCi/L), only 1.5% of the MCL, was detected in the ground water sample collected from on-site well W-373 in June. The maximum tritium activity measured off site in the Livermore Valley was even lower, 9.03 Bq/L, in well 12D2.

Of the Livermore on-site monitoring wells, no inorganic data exceeded primary MCLs, with the exceptions of chromium in monitoring well W-373 and nitrate in monitoring well W-1012. Chromium(VI) in ground water in the vicinity of monitoring well W-373 is being removed at Treatment Facility C (TFC). The LLNL Ground Water Project reports on the treatment of ground water in the vicinity of the treatment facilities (see Chapter 8). Concentrations of nitrate in ground water samples collected from well W-1012 in June 1998 exceeded California's MCL of 45 mg/L. Nitrate above the MCL has not migrated off site. LLNL continues to monitor this well and monitoring well W-571, which is off site and about 350 meters downgradient from well W-1012, to determine if nitrate at concentrations above the MCL migrates off site.

Concentrations of some nonradioactive dissolved metals detected in a few monitoring wells may be of concern. Dissolved chromium(VI) levels in monitoring well W-373 remain at levels greater than California's MCL of 50 µg/L. (Dissolved chromium[VI] in all other wells monitored was found at concentrations less than the MCL.) Ground water in the area of Treatment Facility C has been treated for chromium(VI) since October 1993 (see Chapter 8). The arroyo sediment data included in Chapter 10 indicate no adverse impact on ground water through the arroyos that cross the Livermore site.

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## *Site 300*

Ground water monitoring at Site 300 and adjacent properties in the Altamont Hills shows minimal impact of past and present LLNL operations on ground water beyond the site boundaries.

Within Site 300, the chemicals detected in ground water beneath the High Explosives Process Area will not migrate off site. Plans to remediate TCE, energetic compounds such as RDX, perchlorates, and nitrate are currently being implemented under CERCLA auspices (see Chapter 8). Additionally, LLNL is investigating the distribution and origins of arsenic and zinc in this area.

VOCs, primarily the solvent TCE, have been released historically to shallow ground water at numerous locations at Site 300 (see Chapter 8, and references cited therein). With the exceptions of a small plume in the General Services Area (GSA) area that extends minimally off site along Corral Hollow Road, all of the TCE-bearing ground water is on site. The plume extending off site from the Eastern GSA area is being drawn back to the site by pumping, and the TCE is being removed from the ground water.

Tritiated water and depleted uranium have been released to ground water from landfills and several firing tables in the northern part of Site 300. The boundaries of the slowly moving ground water plumes lie entirely within the site boundaries. Fate and transport models predict that the tritium will decay naturally to an activity below the drinking water MCL before the tritium-bearing ground water reaches a site boundary (Webster-Scholten 1994, Taffet et al. 1996).

Maximum uranium activities that could reach potential exposure points (hypothetical ground water supply wells) at the northern boundary of Site 300 are estimated to be 0.08 Bq/L from plumes originating at Pits 5 and 7, and 0.05 Bq/L at the eastern boundary of Site 300 from the plume originating at Building 850. These conservatively estimated maximum activities are small when compared with the 0.74 Bq/L California MCL for uranium in drinking water. The predicted incremental lifetime cancer risks from the released uranium are less than one-in-a-million at the hypothetical exposure points on the Site 300 boundary (Taffet et al. 1996). The VOCs, tritium, nitrate, Freon, and depleted uranium in the shallow ground water beneath Site 300 present no current health risks because the contaminated water is not used for potable domestic, livestock, or industrial water supplies.

Percolation pits operated in compliance with the conditions of WDR 96-248. Of the seven metals detected in the overflow from the Building 827C percolation pit, three of the metals—copper, lead, and zinc—exceeded recommended water quality criteria, while the concentrations of copper, lead, and zinc exceeded thresholds of aquatic toxicity. However, the discharged water did not reach an on-site drainage channel or Corral Hollow Creek. Therefore, there was no impact on the environment from this one-time overflow.